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APPLICATION NUMBER: *60/615,584*
FILING DATE: *October 05, 2004*

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Menny	SHERMAN	Ramat Gan, ISRAEL

☐ *Additional inventors are being named on the ^ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

TDR MEASUREMENTS OVER ACTIVE TELEPHONE LINES

CORRESPONDENCE ADDRESS

Direct all correspondence to:

☒ Customer Number 27130 *Type Customer Number here* → *Place Customer Number Bar Code Label here*

OR

☒ Firm or Individual Name	Eitan, Pearl, Latzer & Cohen Zedek, LLP.				
Address	10 Rockefeller Plaza				
Address	Suite 1001				
City	New York	State	New York	ZIP	10020
Country	USA	Telephone	212-632-3480	Fax	212-632-3489

ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages* 7 ☐ CD(s), Number

☒ Drawing(s) *Number of Sheets* 9

☐ Application Data Sheet See 37 CFR 1.76 ☒ Other (specify) postcard

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT *(check one)*

☐ Applicant claims small entity status See 37 CFR 1 27

☐ A check or money order is enclosed to cover the filing fees

☒ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 05-0649

FILING FEE AMOUNT ($) 160.00

☐ Payment by credit card Form PTO-2038 is attached

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government

☒ No

☐ Yes, the name of the U S Government agency and the Government contract number are:

Respectfully submitted,

Date 05 / Oct / 2004

SIGNATURE

TYPED or PRINTED NAME Guy Yonay

TELEPHONE 212-632-3480

REGISTRATION NO *(if appropriate)* 52,388

Docket Number: P-7258-USP

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

This collection of information is required by 37 CFR 1 51 The information is used by the public to file (and by the PTO to process) a provisional application Confidentiality is governed by 35 U S C 122 and 37 CFR 1 14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the complete provisional application to the PTO Time will vary depending upon the individual case Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U S. Patent and Trademark Office, U S Department of Commerce, Washington, D C. 20231 DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS SEND TO: Provisional Application, Commissioner for Patents, P O Box 1450, Alexandria. VA 22313-1450

TIME DOMAIN REFLECTOMETER (TDR) MEASUREMENTS OVER ACTIVE TELEPHONE LINES

BACKGROUND OF THE INVENTION

Copper cables have been used for many years by carriers to provide telephone service to the local customers. The evolution of technology and the growth of bandwidth demand created new challenges for the carriers owning the copper infrastructure, such as maximizing the utilization of the network for transmitting both data and voice while avoiding the installation of new infrastructures.

Accurate detection of transmission line faults and line length measurement are important for determining the line's quality, especially when considering using the line for transmitting high data rate services such as DSL. This is being done as part of pre-qualification process, in which each copper twisted pair is examined prior the DSL installation for evaluating its capability to provide the required performance for such services. Some DSL services can be combined with existing services, for example ADSL can be added to existing regular telephone service (POTS) or ISDN service, and therefore not only unused pairs should be qualified for DSL but active POTS or ISDN pairs as well.

In order to discover a copper pair's impairments and to figure out whether its length is appropriate for the operation of DSL service, a Time Domain Reflectometer (TDR) is commonly used. TDR can discover discontinuity at the transmission line and measure transmission line impedance. TDR testing typically involves a pulse generator launching a fast edge pulse into the transmission line under investigation. A receiver, e.g., an oscilloscope, then monitors the resulting reflected pulses. Such reflections are caused by any impedance discontinuity such as end of line or other impairments, and therefore the TDR technique can discover the position and nature (e.g., high or low impedance) of each discontinuity along the line under test. The location of each discontinuity may be calculated according to the time delay between the transmitted pulse and the received reflection.

FIG.1 shows a typical Telco infrastructures network. The telephony switch 110 and the Main distribution frame (MDF) 150 are positioned inside the Telco central office (CO) 100. The Street cabinet 170 is distributing the copper pairs to smaller distribution points (DP) 180 and from there to the subscribers 190. Several cable segments are connected between the different locations. Each active line card 120 at the switch is wired to the MDF 150 using twisted pair wires 130, named Tip and Ring. A jumper 140 is used for cross-connecting between the two sides of the MDF, while a multi pair cable 155 is connecting a group of pairs to the street cabinet 170. A jumper 175 is cross-connecting between the street cabinet's two sides of termination blocks, where another cable connects the pair to a distribution point (DP) 180 and to the subscriber 190. Some unused pairs between the MDF and the street cabinet might not be connected to the switch but only be spare pairs for future use.

FIG. 2 shows a typical TDR testing setup. A TDR tester 200 comprises of a pulse generator 210 and a receiver 220. The pulse generator 210 transmits a pulse wave E_s that is applied to a transmission line 240 with a termination device 230. The voltage step E_s travels along the transmission line 240 at the velocity of propagation of the transmission line. If load impedance Z_L is equal to the characteristic impedance of transmission line 240, no wave is reflected and only the transmitted pulse E_s will be seen at receiver 220. If a mismatch exists at load Z_L, part of the wave E_s is reflected. The reflected voltage wave E_r will be recorded at the receiver added to the transmitted wave. The reflected wave can be identified in time domain due to its delay from the transmitted wave. This time difference between the pulses is used to determine the length of transmission line 240 between the monitoring point and the termination point.

Conventionally, TDR measurements are done on unused pairs in order to avoid echo pulses or interferences from active devices such as Line Cards (LC) placed at the Telco switch. Furthermore the TDR tester is positioned at the end of the line in order to provide an impedance match to the line and absorb all reflected pulses, while interfacing the line at a different point creates a backward segment, which causes impedance mismatch, additional reflections and energy loss.

The need to disconnect the pairs from the switch before testing results from the electrical behavior of the line card – the basic unit to which each line is connected and provides the

interface between the switching network and the telephone line. The electrical circuit on the line card usually consists of capacitors and inductors as part of its analogue interface. When trying to apply TDR pulse at a point near the line card without disconnecting it, the line card impedance might cause undesired signals, which will disrupt the TDR receiver from detecting the returned pulse from the far end of the line. Such signals might appear as strong oscillations, which will screen the desired signal altogether. The existence of variety of line cards designs, which use different technologies, causes different effects, which are hard to predict and repair.

Therefore the common use of TDR devices requires the disconnection of the tested line from the switch. When performing mass qualification process in an automatic manner this requirement becomes very tedious and time consuming. Alternative existing solution includes adding disconnection matrix to the Telco infrastructure, which may be very expansive and sometimes impractical to implement in an operating network. Furthermore the use of the existing test bus of the switch, which is used for line testing, is not suitable for TDR measurement, since the test bus acts as a low pass filter and disrupts the high frequency TDR pulse.

Figure 3 shows practical TDR measurement setup of an active pair as performed in prior art. Twisted pair 130 is an active pair connected to a line card 120, and is to be evaluated for carrying ADSL service. In order to measure the line length the pair must be manually disconnected from the line card for example at point 310 located at the MDF termination blocks. The TDR tester 200 is then connected to the open end of the line, and the measurement is performed, as it was an unused pair. When the TDR measurement is done the pair is manually connected back to the line card. When a mass qualification is required on large amount of pairs, the same process should be performed repeatedly. The result is a tedious time consuming process, which causes line interruptions to the service and is sensitive to human errors.

The purpose of the invention is to provide a solution, which will enable testing of twisted pair telephone lines using TDR technology without need to physically disconnect the lines from the switch. Such a solution is critical when mass qualification is required on large amount of pairs.

DECSRPITION OF THE INVENTION

The principal of the current invention is based on a method to neutralize the line card effect from disturbing the TDR measurement. This is being done by shorting the tip and ring wires at the point of access to the line 410 as shown at figure 4. Shorting the two wires simulates off-hook scenario at the line card and neutralizes the line card's interface from creating any signal paths, which might cause interference. In order to perform the TDR measurement two alternative terminals are being used at the tester: The first is the access point to the line 420, which is actually connected to both Tip and Ring, and the second 430 is a grounding point of the central office. Since grounding exists at the cable itself, the central office, the street cabinet and the subscriber home, it can be regarded as a grounding plane, which enables closing electrical circuit from the access point at the central office to the end of the line and back.

In order to perform the measurement automatically and without any dependency on the switch, the testing system accesses the lines at the Main Disturbing Frame (MDF) at the central office, using front tap shoes connectors 520 such as those designed by RiT technologies, and are freely attached to the MDF wiring blocks 500 (Figure 5). Such connector may include 100 contacts to be attached to 100 twisted pairs simultaneously. A multi pair cable 530 is connecting the shoe to the test front end 570. The test front end purpose is to enable the performance of automatic connection of the Tip and Ring of a certain pair thus making a shorted point at the MDF and enabling measurement between this point and ground. The test front end comprises of line selector unit 540, test configuration unit 510, DC voltmeter 580, and control interface unit 550. The line selector unit 540 is capable of selecting any pair out of the 100 using array of relays, in which only one path is enabled at a time to connect the selected pair to the system. The test configuration unit 510 is capable of shorting the Tip – Ring wires of the selected pair and connecting the short point to one of the TDR device terminals. The other terminal is connected to the ground point as explained above. After the desired line and the required configuration are selected, the TDR device 200 sends a pulse, monitors the reflected pulses and measures the time delays between the transmitted and the reflected pulses. The

end of line distance or the location of the impairment points are calculated according to the time delay measurement, and the cable velocity of propagation, as being traditionally done in TDR technology. A standard computer preferably a portable PC 560 is responsible for the hardware commands and data processing. The control interface unit 550 translates the PC standard RS232 interface into switching command signals by using digital circuitry. Any interface such as RS232 can be used for accessing the TDR device through serial cable 590 or any other mean. This interface is used for sending commands from the PC to the TDR and receiving the data results from the TDR tester. All processes are controlled from the application software, which manages the testing commands and processes the results.

The same process is done for each of the pairs. After the first pair is switched, shorted and measured, the short is opened and the pair returns to its original status. Then a relay connects the second pair to the testing system and the same process repeats. All 100 pairs can be tested automatically without any manual action required. In order to avoid interference to busy lines, which carry telephone calls at the moment of the test, a preliminary voltage measurement is being made before testing the line by the DC voltmeter 580. If the DC voltage drops beyond certain threshold (e.g. 15V), the line is identified as busy line, and is not being shorted and tested. All busy lines are entered to a re-try list, and re-accessed after a certain period of time. When all pairs are tested the same process can be applied to another set of pairs.

It should be cleared that any number of pairs may be used for simultaneous access at the shoe and the number 100 is mentioned only as an example.

Figure 6 describes the test configuration unit 510 in more details. S1,S2,S3,S4,S5,S6,S7,S8 are two states relays, which enable different test configurations. S1, S2 enables a direct connection of Tip and Ring to the tester input. S3, S4 performs short between the Tip and Ring. Selection of S5 or S6 connects the shorted Tip –Ring to one of the tester's terminals. Selection of S7 or S8 connects the ground to the other tester's terminal. For example – typical measurement will require closing s3, s4, s5, s8 while all other relays are open.

The described system's advantages are the capability to measure large number of active lines automatically and efficiently at the MDF by using a removable connector, without

any need to interface the telephony switch. The result of the process is accurate length and impairment points distance measurement, which cannot be performed otherwise without manually disconnecting the lines from the switch.

Fig 7 shows a TDR testing setup of another suggested method, which enables the performance of a TDR measurement without any interruption to the telephone service. A Low Pass Filter 700 is placed between the Tip – Ring wires and the TDR tester. This filter isolates the Tip – Ring wires at voice band frequencies enabling continues telephony service, while acting as short at higher frequencies, in which the TDR transmits (Figure 8). In this way the same shorting mechanism is applied to the pairs without interrupting the voice service. Figure 9 shows an alternative test configuration unit, which includes the low pass filter option. The filter mode can be operated by closing relays s9, s10, s11, s8 or by closing s7, s9, s10, and s12.

CLAIMS:

What is claimed is:

1. A system substantially as described hereinabove.
2. A system substantially as illustrated in any of the drawings.
3. A device substantially as described hereinabove.
4. A device substantially as illustrated in any of the drawings.
5. A method substantially as described hereinabove.
6. A method substantially as illustrated in any of the drawings.

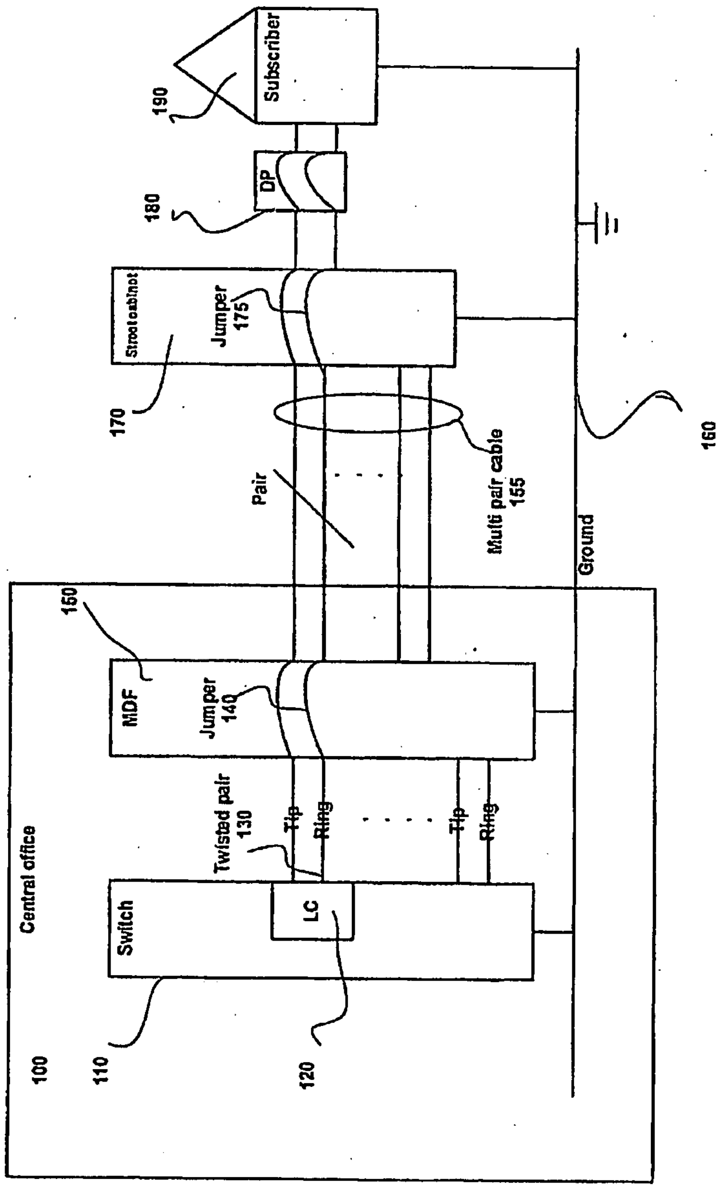

Central office
100
Switch
110
LC
120
Twisted pair
130
Tip
Ring
MDF
150
Jumper
140
Pair
Multi pair cable
155
Ground
160
Streetcabinet
170
Jumper
175
DP
180
Subscriber
190

Figure 1

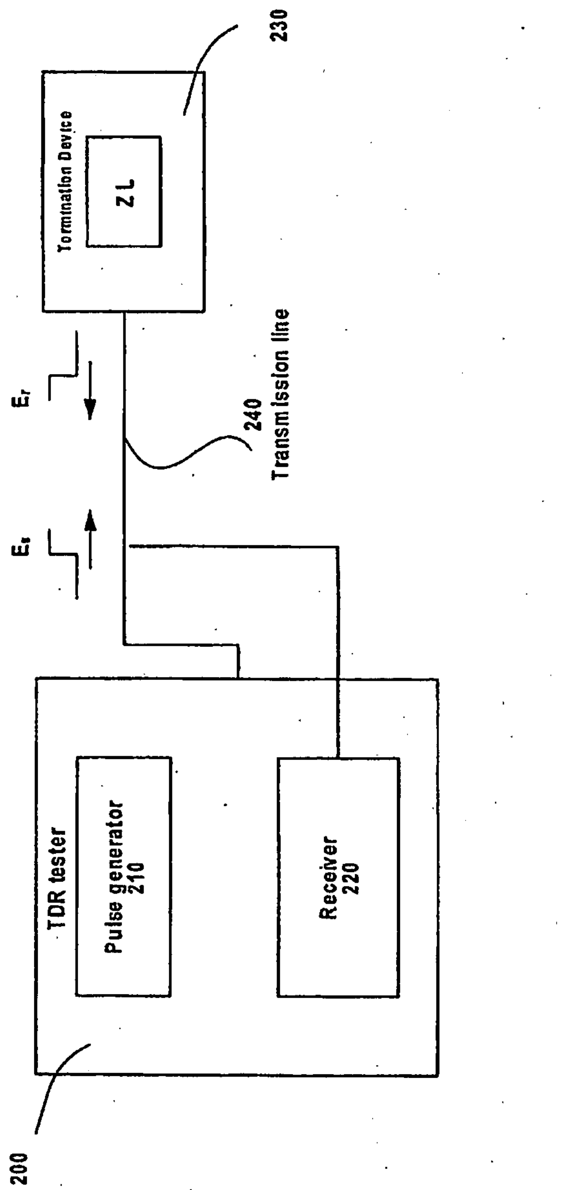

230
Termination Device
ZL
E_r
E_s
240
Transmission line
TDR tester
Pulse generator
210
Receiver
220
200

Figure 2

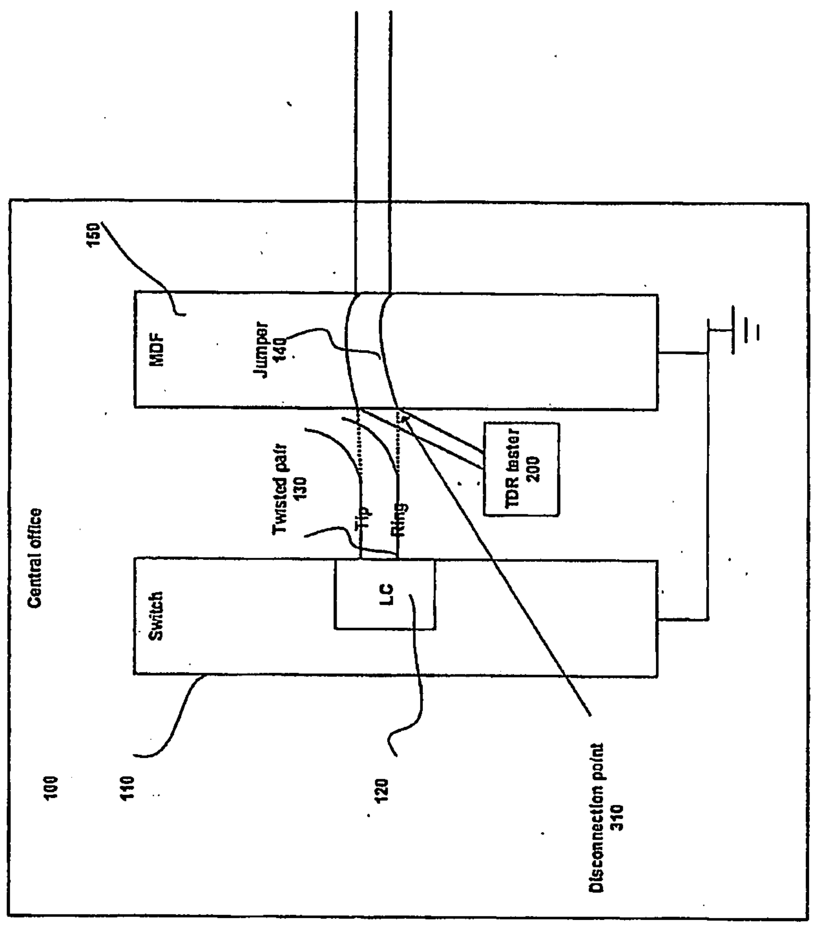

Central office
100
Switch
110
LC
120
Twisted pair
130
Tip
Ring
MDF
150
Jumper
140
TDR tester
200
Disconnection point
310

Figure 3

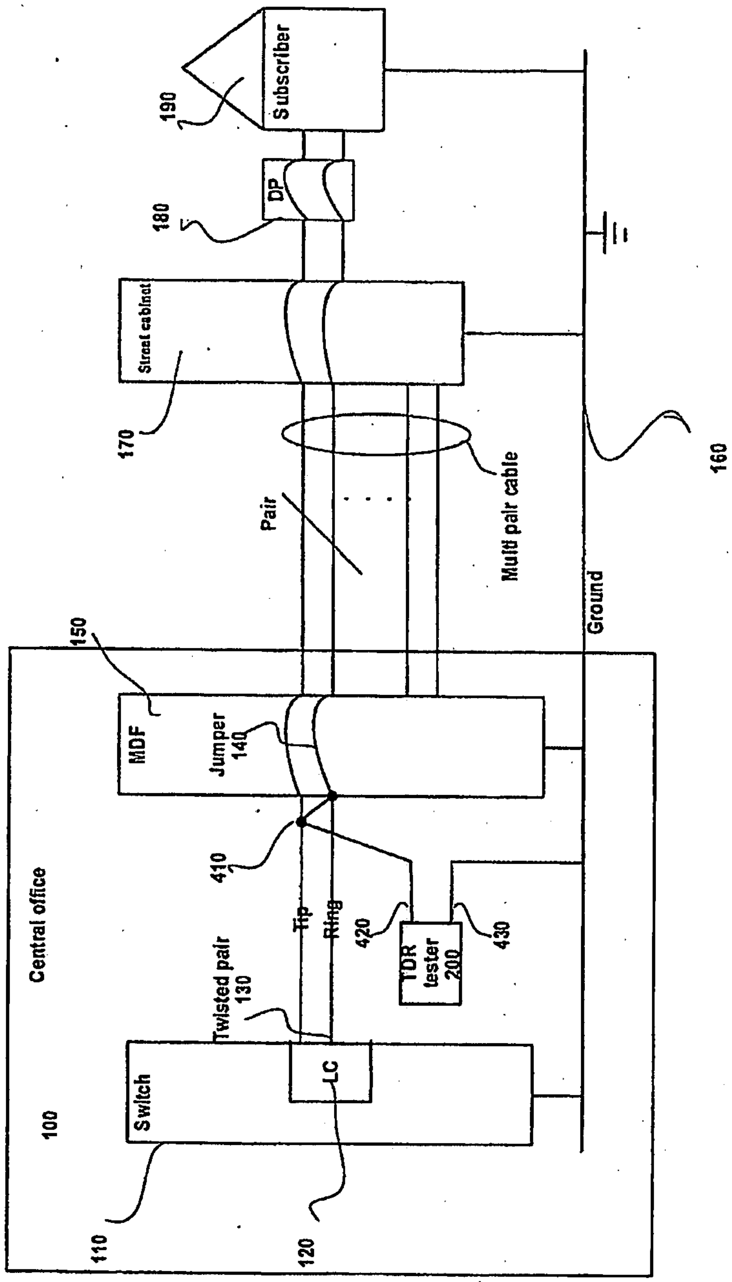

Subscriber
190
DP
180
Street cabinet
170
Pair
Multi pair cable
160
Ground
150
MDF
Jumper
140
410
Central office
Twisted pair
130
Tip
Ring
420
TDR
tester
200
430
Switch
LC
100
110
120

Figure 4

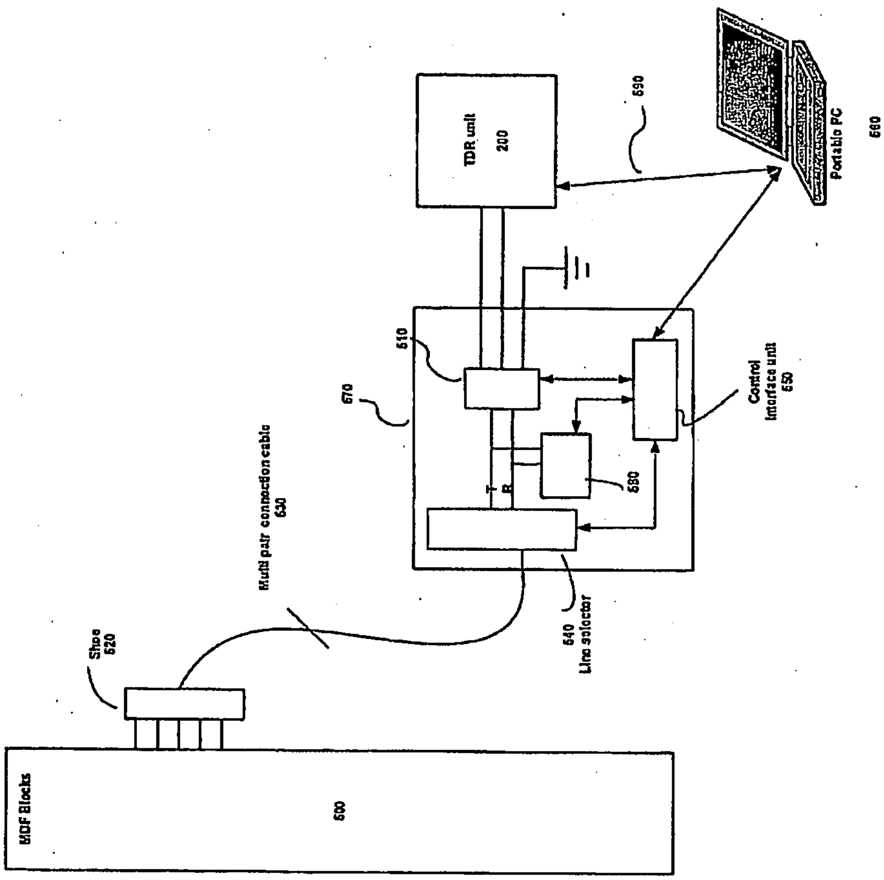

TDR unit
200
Portable PC
Control
interface unit
550
Multi pair connection cable
530
Line selector
Shoe
520
MDF Blocks
T
R

Figure 5

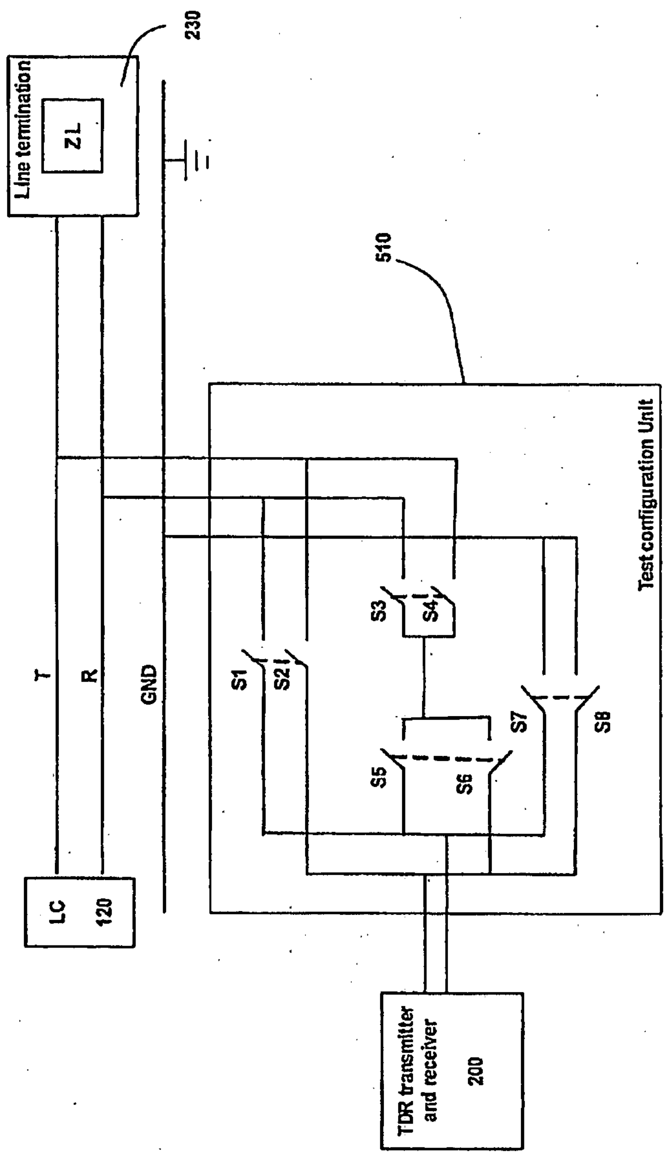

230
Line termination
ZL
510
Test configuration Unit
T
R
GND
S1
S2
S3
S4
S5
S6
S7
S8
LC
120
TDR transmitter
and receiver
200

Figure 6

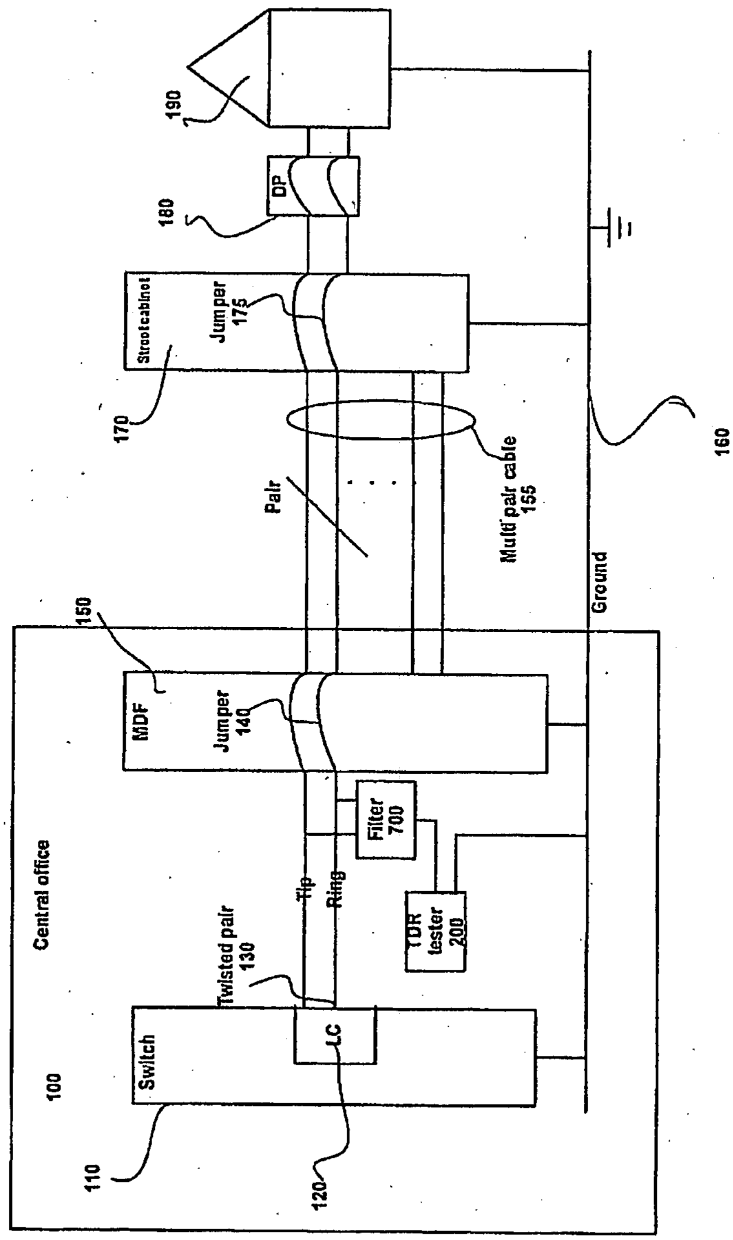

190
180
DP
Streetcabinet
Jumper
175
170
Pair
Multi pair cable
155
160
Ground
150
MDF
Jumper
140
Filter
700
Central office
Tip
Ring
TDR
tester
200
Twisted pair
130
LC
Switch
100
110
120

Figure 7

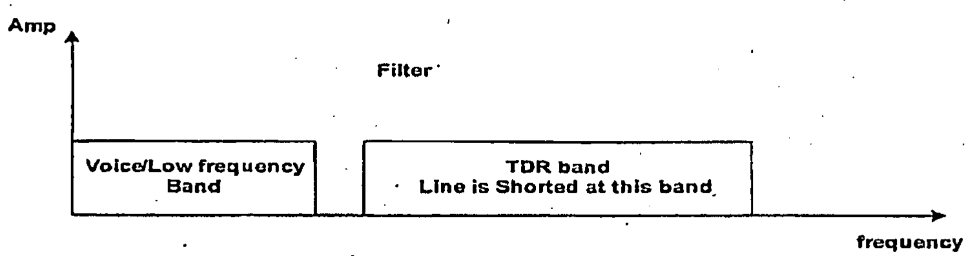
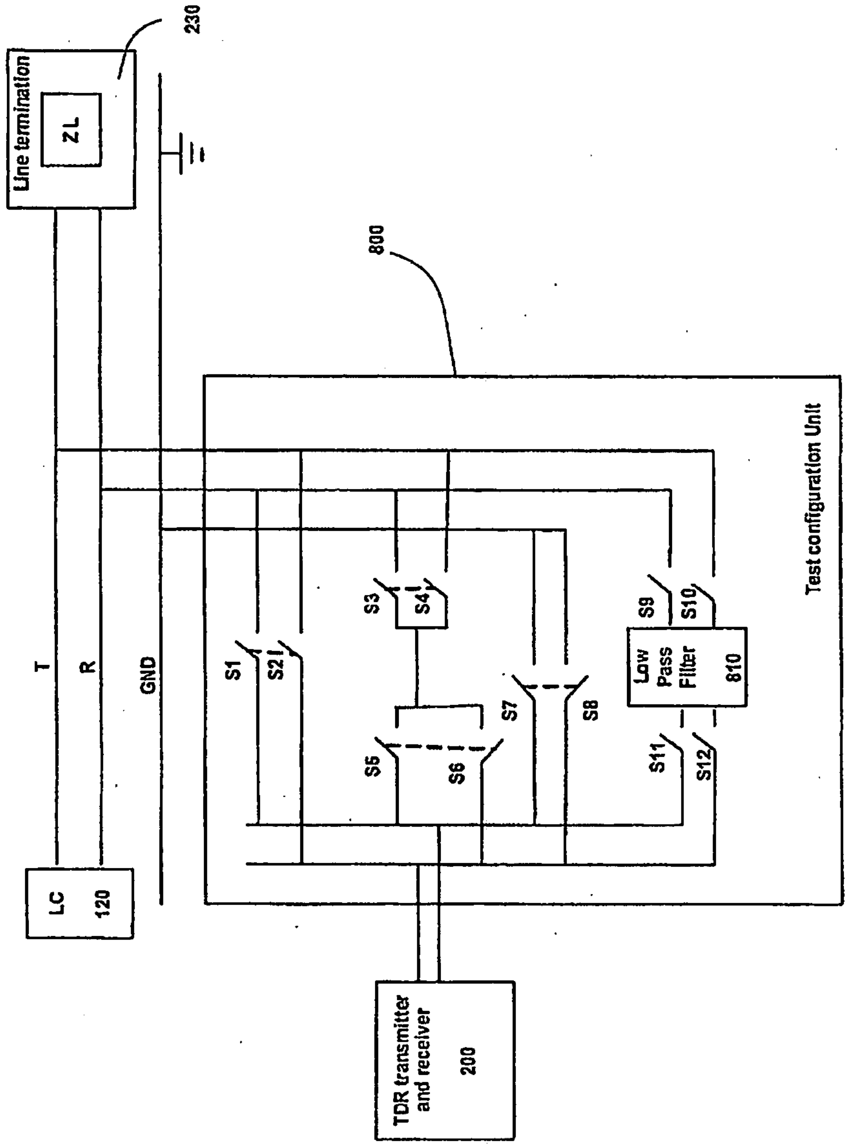

Amp
Filter
Voice/Low frequency Band
TDR band
Line is Shorted at this band
frequency

Figure 8



230
Line termination
ZL
800
Test configuration Unit
T
R
GND
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
Low Pass Filter
810
LC
120
TDR transmitter and receiver
200

Figure 9